STORK® Cryenco

TADOPTR DEVELOPMENT PROGRAM

Overview

In 1994, Cryenco obtained the licensing rights to a new cryogenic refrigeration technology - Thermo-acoustically Driven Orifice Pulse Tube Refrigeration (TADOPTR). This technology has the unique capability of producing refrigeration power at cryogenic temperatures with no moving parts. Cryenco and Stork are jointly developing this technology for application of liquefying natural and industrial gases. The technology is well suited for liquefaction capacities in the range of roughly 500 to 50,000 gallons per day (approximately 4.5 mmscfd). There are no technical barriers to developing systems with larger capacities.

Development Program

Cryenco's development program for TADOPTR has been divided into three phases. Phase I: development of a system with a liquefaction capacity of nominally 500 gallons per day (GPD). Phase II: development of a system with a liquefaction capacity of 10,000 GPD. These systems will fit on a standard, flat bed truck. Phase III will be development of a 20,000 – 50,000 GPD system. Cryenco passed a significant milestone in Phase I; demonstration of an engineering prototype TADOPTR which successfully liquefied a stream of natural gas at a rate of 140 GPD. Cryenco plans to complete the development of the 500 GPD TADOPTR in 1999.

Background

Thermoacoustically driven orifice pulse tube refrigeration was first demonstrated in 1989 by scientists from Los Alamos National Laboratory (LANL) and the National Institute of Standards and Technology (NIST). This demonstration was the successful marriage of two separate, but synergistic technologies - Thermoacoustic Drivers (TADs) developed at LANL and Orifice Pulse Tube Refrigeration (OPTR) developed at NIST. The synergy is that neither technology requires any moving parts

The first demonstration unit at LANL reached a temperature of -150°C with a refrigeration power equivalent to only about a 1/4th of a gallon per day. The TADOPTR was patented by LANL. As part of the technology transfer program of the national laboratories, licensing rights to the technology were made available to private industry interested in commercialization. In 1993, Cryenco entered into a licensing agreement with LANL for the technology for the liquefaction of gases.

The TADOPTR

Operation

The TADOPTR consists of three major components.

1. The power source, a natural gas burner.
2. The TAD, a converter which changes the thermal input power to acoustic power, i.e. a pressure oscillation.
3. The OPTR, another converter which changes the acoustic power into heat removal, or thermal extraction power.

Heating one end of the TADOPTR to 750°C, the other end cools to -150°C. The only thing moving within the system is the working gas, typically helium. By creating a large temperature difference across a short section of a resonator pipe filled with a helium, the helium goes into spontaneous pressure oscillations. These oscillations are sustained by maintaining the required temperature difference with the continuous input of heat by a burner.

The OPTR operates on a modified Stirling refrigeration cycle, but the cold, moving displacer in a Stirling system is replaced by a gas column (or pulse tube), an orifice and a reservoir; all static components. The orifice/reservoir causes the helium to cycle between a cold, heat extracting exchanger when the helium has been expanded and cooled by the TAD, and a warm, heat rejection exchanger when the helium has been subsequently compressed and heated by the TAD. Thus, the OPTR pumps thermal energy from a cold reservoir to a warm reservoir like any refrigeration device. The initial performance target for the TADOPTR is to burn 30% of an incoming natural gas stream to liquefy the remaining 70%. This is projected to improve as development continues.

Description

The three components of a TADOPTR have three different characteristic dimensions. The OPTR is small; a 500 GPD unit has a characteristic dimension of a few feet. The burner is medium-sized, its length is 1 to 3 m. The TAD is large, its length is roughly 12 m. (Its diameter is only a about 12 inch for a 500 GPD unit.) The TAD length is a function of the operating frequency chosen for the TADOPTR system, which, in turn, is a function of optimization of a number of system operating parameters. A picture of the first, large scale TADOPTR built by Cryenco is shown on the front page. The OPTR is the vertical section at the front, the TAD is at the back end of the long resonator tube in the middle, and the natural gas burner is at the back end of the TAD. This unit has produced 140 GPD of liquefied natural gas (LNG).

Financing

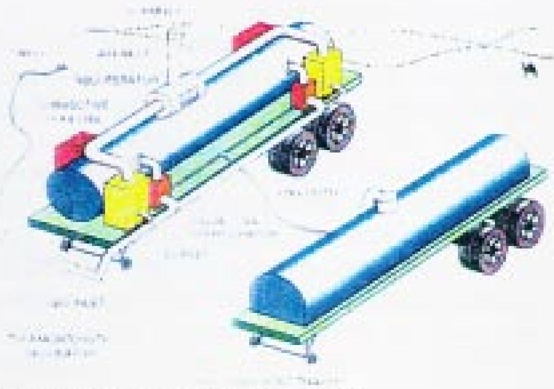
After obtaining the licensing rights to TADOPTR, Cryenco raised $800K in private venture capital funds to support the initiation of Phase I. In May 1995, Cryenco received a contract for $452K from the Advanced Research Program Agency of the U.S. Government, most of which has been directed toward supporting Phase I TADOPTR development. In addition to these sources, Cryenco has invested considerable internal funds in support of the program. The U.S. Department of Energy funds LANL to pursue fundamental research on thermoacoustics in parallel with Cryenco's commercialization efforts.

Recently, Cryenco has granted Stork the exclusive licensing rights for gas liquifaction for the following applications: oil and gas, refining, and energy industry, generally for larger capacities. In return, Stork supports the Development Program, both technically and financially. Stork intends to enable a selected number of oil companies and contractors to participate in the Development Program.

Markets

Cryenco and Stork are investigating numerous potential market applications for the TADOPTR, for both the small scale, 500 GPD units and larger scale systems, 10,000-50,000 GPD units. Those applications include: natural gas liquefaction at remote gas and oil wells, natural gas liquefaction at offshore oil wells, natural or industrial boil-off gas reliquefaction at large scale storage facilities, industrial gas liquefaction in conjunction with air separation systems, natural gas liquefaction from landfill and waste water treatment facilities, natural gas liquefaction from pipeline gas for application to the transportation and other industries.

For the natural gas liquefaction applications, another attractive feature of this technology is that the power source is also natural gas.



Artist's rendering of the TADOPTR

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